

IN THE CLAIMS:

1 1.-22. (Cancelled)

1 23. (Currently Amended) A storage system, comprising:

2 a destination storage device configured to store a copy of data from a source stor-
3 age device;

4 a snapshot storage device configured to store a snapshot version of the data from
5 the source storage device;

6 a ~~first~~ process configured to initiate a copy operation of the source storage device,
7 wherein the copy operation is configured to copy each block of the source storage device
8 to the destination storage device, and wherein the copy operation is performed in seg-
9 ments, and wherein each segment is a range of data bytes of the source storage device;

10 the storage system configured to receive a write request to modify a requested
11 range of data bytes of the source storage device while the copy operation of the source
12 storage device is in progress, wherein the write request to modify the requested range of
13 data bytes is a write request range;

14 the storage system further configured to determine ~~if~~ that the write request range
15 falls within the range of data bytes of the source storage device being copied while the
16 copy operation is in progress;

17 in response to determining that the write request range falls within the range of
18 data bytes of the source storage device being copied while the copy operation is in pro-
19 gress, the storage system ~~is~~ further configured to determine if a particular range of the
20 range of data bytes of the source storage device to be modified by the write request range
21 has already been written to ~~a~~ the snapshot storage device;

22 in response to determining that the particular range of the range of data bytes of
23 the source storage device to be modified by the write request range has already been writ-
24 ten to the snapshot storage device, the copy operation further configured to copy one or
25 more bytes of the particular range of range of data bytes from the snapshot storage de-

26 | ~~vice~~ write request is configured to be written to the source-destination storage device, the
27 | process further configured to write the write request to the source storage device; and
28 | in response to determining that the particular range of the range of data bytes of
29 | the source storage device to be modified by the write request range has not already been
30 | written to the snapshot storage device, a second ~~the process is further~~ configured to copy
31 | the particular range of the range of data bytes of the source storage device to the snapshot
32 | storage device, the second ~~process is further~~ configured to write the write request to the
33 | source storage device.

1 24. (Previously Presented) The storage system of claim 23, wherein the source storage
2 device is organized in a RAID system.

1 25. (Previously Presented) The storage system of claim 23, wherein the storage system
2 is further configured, in response to determining the write request range falls within the
3 range of bytes being copied, to hold the write request in a cache and update a snapshot
4 map.

1 26. (Currently Amended) The storage system of claim 23, ~~wherein further comprising a~~
2 server configured to execute the ~~first process and the second process.~~

1 27. (Previously Presented) The storage system of claim 26, wherein the server is opera-
2 tively connected to a storage area network switch and the server is further configured to
3 communicate with the storage system through the storage area network switch.

1 28. (Previously Presented) The storage system of claim 23, wherein the process is con-
2 figured to control multiple storage systems.

1 29. (Currently Amended) The storage system of claim 23, wherein the write request ~~in-~~
2 ~~cludes~~ comprises a SCSI commands.

1 30. (Previously Presented) The storage system of claim 23, wherein the storage system
2 is further configured to send one or more commands by using an in-band protocol.

1 31. (Currently Amended) A method, comprising:

2 starting a copy command from a source storage device to a destination storage
3 device, wherein the copy command copies each block of the source storage device to the
4 destination storage device, the copy command being performed in segments and each
5 segment specifying a range of data bytes of the source storage device;

6 receiving a write request to modify a requested range of data bytes of the source
7 storage device while the copy command is in progress, wherein the write request to mod-
8 ify the requested range of data bytes is a write request range;

9 determining if the write request range falls within the range of data bytes of the
10 source storage device being copied;

11 determining, in response to the write request range falling within the range of data
12 bytes of the source storage device being copied, if a particular range of the range of data
13 bytes of the source storage device to be modified by the write request range has already
14 been written to a snapshot;

15 ~~writing~~ copying, in response to the particular range of the range of data bytes of
16 the source storage device to be modified by the write request range having already been
17 written to the snapshot, one or more bytes of the particular range of range of data bytes to
18 the destination storage device from the snapshot~~the write request to the source storage~~
19 ~~device~~; and

20 copying, in response to the particular range of the range of data bytes of the
21 source storage device to be modified by the write request range having not already been
22 written to the snapshot, the particular range of the range of data bytes to the snapshot, and
23 then writing the write request to the source storage device.

1 32. (Previously Presented) The method of claim 31, wherein the source is organized in a
2 RAID system.

- 1 33. (Previously Presented) The method of claim 31, further comprising:
2 in response to determining the write request range falls within the range of data
3 bytes of the source storage device being copied, holding the write request command in a
4 cache, and updating a snapshot map associated with the snapshot.
- 1 34. (Previously Presented) The method of claim 31, further comprising:
2 executing the copy command by a replication manager.
- 1 35. (Previously Presented) The method of claim 31, further comprising:
2 connecting a server to a storage area network switch and communicating with a
3 storage system through the storage area network switch to execute the copy command.
- 1 36. (Previously Presented) The method of claim 31, further comprising:
2 controlling multiple storage device controllers by a replication manager.
- 1 37. (Previously Presented) The method of claim 31, wherein the write request comprises
2 a SCSI command.
- 1 38. (Currently Amended) The method of claim 31, further comprising:
2 | sending a storage system commands using one of an in-band protocol or an out-
3 of-band protocol.
- 1 39. (Currently Amended) A computer-implemented method, comprising:
2 starting a copy operation by copying data from a source storage device to a desti-
3 nation storage device, the copy operation being performed in segments, and each segment
4 having a range of data bytes of the source;
5 receiving a write request to modify a requested range of data bytes of the source
6 storage device while the copy operation is in progress, wherein the write request to mod-
7 ify the requested range of data bytes is a write request range;

8 determining if the write request range falls within the range of data bytes of the
9 source storage device being copied;

10 determining, in response to the write request range being in the range of data
11 bytes of the source storage device being copied, if a particular range of the range of data
12 bytes of the source storage device to be modified by the write request range has been
13 written to a snapshot;

14 ~~writing~~copying, in response to the range of data bytes of the source storage device
15 to be modified by the write request range having been written to the snapshot, one or
16 more bytes of the particular range of data bytes to the destination storage device from the
17 snapshot storage~~the write request to the source storage device~~; and

18 copying, in response to the range of data bytes of the source storage device to be
19 modified by the write request range having not been written to the snapshot, the particu-
20 lar range of the range of data bytes of the source storage device to the snapshot, and then
21 writing the write request to the source storage device.

1 40. (Currently Amended) A system, comprising:

2 a destination storage device configured to store a copy from a source storage de-
3 vice;

4 a snapshot storage device configured to store a snapshot version of the data from
5 the storage device;

6 a ~~first~~ process configured to initiate a copy operation of the source storage device
7 wherein the copy operation ~~includes~~ comprises copying each block of the source storage
8 device to the destination storage device, the copy operation being performed in segments,
9 and each segment having a range of data bytes of the source storage device;

10 the system configured to receive a write request to modify a requested range of
11 data bytes of the source storage device while the copy operation is in progress, wherein
12 the write request to modify the requested range of data bytes is a write request range;

13 the system further configured to determine ~~if that~~ the write request range falls
14 within the range of data bytes of the source storage device being copied;

15 in response to determining that the write request range falls within the range of
16 bytes of the source storage device being copied, the system further configured to deter-
17 mine if a particular range of the range of data bytes of the source storage device to be
18 modified by the write request range ~~have~~has been written to a snapshot of the snapshot
19 storage device;

20 in response to determining that the particular range of the range of data bytes of
21 the source storage device to be modified by the write request range ~~have~~has been written
22 to the snapshot, the process further configured to copy one or more bytes of the particular
23 range of the range of data bytes to the destination storage device from the snapshot~~the~~
24 ~~write request to be written to the source storage device~~; and

25 in response to determining that the particular range of the range of data bytes of
26 the source storage device to be modified by the write request range ~~have~~has not been
27 written to the snapshot, ~~the a second~~ process further configured to copy the particular
28 range of the range of data bytes of the source storage device to the snapshot, ~~and then the~~
29 ~~second~~ process further configured to write the write request to the source storage device.

1 41. (Currently Amended) The system of claim 40, wherein the ~~first process and the sec-~~
2 ~~ond process are~~ is executed on a file server and is further configured to control the source
3 storage device and one or more other storage devices.

1 42. (Currently Amended) The system of claim 40, further comprising ~~wherein~~ a list
2 comprising of source storage device data blocks to be copied, wherein the list is config-
3 ured to be reordered.

1 43. (Currently Amended) The system of claim 42, wherein the list of source storage de-
2 vice data blocks to be copied is buffered while the system awaits further copy commands.

1 44. (Currently Amended) The system of claim 40, wherein the ~~first process and the sec-~~
2 ~~ond process are~~ is further configured to insert control data before and after a source stor-
3 age device data block is copied.

1 45. (Currently Amended) The system of claim 40, wherein the ~~first process and the sec-~~
2 ~~ond process are~~ is further configured to specify a block size so that the storage system
3 writes one or more fixed-size blocks.

1 46. (Currently Amended) A method, comprising:

2 receiving a write request while a copy operation is in progress wherein the copy
3 operation ~~includes~~ comprises copying each block of the source to the destination, the
4 copy operation being performed in segments, and each segment has a range of data bytes
5 of the source, the write request to modify a requested range of data bytes in a source stor-
6 age device, wherein the write request to modify the requested range of data bytes is a
7 write request range;

8 determining if the write request range being copied falls within a particular range
9 of the range of bytes of the source storage device to be modified by the write request
10 range;

11 determining that the particular range of the range of bytes of the source storage
12 device to be modified by the write request range ~~have~~ has not been written to a snapshot;

13 in response to determining that the particular range of the range of bytes of the
14 source storage device to be modified by the write request range ~~have~~ has not been written
15 to the snapshot, copying the particular range of the range of bytes of the source storage
16 device to be modified by the write request range to the snapshot before modifying the
17 particular range of the range of bytes of the source storage device;

18 in response to determining that the particular range of the range of bytes of the
19 source storage device to be modified by the write request range has been written to the
20 snapshot, copying one or more bytes of the particular range of the range of data bytes to
21 the destination from the snapshot;

22 updating a snapshot map, wherein the snapshot map indicates which blocks of the
23 range of bytes are located in the snapshot; and

24 modifying the particular range of the range of bytes of data in the source storage
25 device from the write request.

1 47. (Currently Amended) The storage system of claim 23, further comprising:
2 a first in first out queue configured to buffer the write request in response to de-
3 termining that the particular range of the range of data bytes of the source storage device
4 to be modified by the write request range ~~have~~has not been written to the snapshot.

1 48. (Currently Amended) The method of claim 31, further comprising:
2 placing the write request in a first in first out queue in response to determining
3 that the particular range of the range of data bytes of the source storage device to be
4 modified by the write request range ~~have~~has not been written to the snapshot.

1 49. (Currently Amended) A computer-readable storage media containing executable
2 program instructions executed by a processor, comprising:
3 program instructions that receive at a source storage device a write request issued
4 from a storage system, the write request specifying a first range of data bytes of the
5 source storage device, the write request being received while the source storage device is
6 being copied to a destination storage device; ~~and~~
7 in response to receiving the write request, program instructions that hold the write
8 request in a cache;
9 program instructions that check if the first range overlaps with a ~~second range,~~
10 ~~wherein the second range is a~~ particular range of the range of data bytes of the source
11 storage device to be modified by the write request that is being copied to the destination
12 storage device;
13 program instructions that determine if the particular range of the range of data
14 bytes of the source storage device to be modified by the write request has already been
15 written to a snapshot storage device;
16 in response to the first range overlapping with the ~~second-particular~~ range of data
17 bytes of the source storage device to be modified by the write request already having
18 been written to the snapshot storage device, program instructions that copy one or more

19 | bytes of the second-particular range of the range of data bytes from the snapshot storage
20 | device to the destination device~~source storage device to a snapshot;~~

21 | program instructions that update a snapshot map; and

22 | program instructions that allow the write request to write to the source storage de-
23 | vice.

1 | 50. (Currently Amended) A method for making a copy of data in a database, compris-
2 | ing;

3 | starting a copying operation of a source storage device to a destination storage
4 | device, wherein the copy operation is performed in segments and each segment is a range
5 | of data bytes of the source storage device, the copy operation started at a begin time;

6 | maintaining a snapshot volume that includes each block of the source storage de-
7 | vice that has a write request directed to that block during the course of the copy opera-
8 | tion;

9 | receiving a write request directed to a particular range of the range of data bytes
10 | to be modified by the write request range that currently is being copied to the destination
11 | storage device;

12 | in response to determining that the particular range of the range of bytes to be
13 | modified by the write request range has been copied to the snapshot volume, continuing
14 | the copy operation to the destination storage device using one or more bytes of the par-
15 | ticular range of the rang of data bytes from the snapshot;

16 | in response to determining that the particular range of the range of bytes to be
17 | modified by the write request range ~~have~~has not been copied to the snapshot volume,
18 | holding the write request until the particular range of the range of bytes to be modified by
19 | the write request range ~~are~~is copied to the snapshot volume;

20 | after completion of writing the particular range of the range of bytes to be modi-
21 | fied by the write request range to the snapshot volume, executing the write request on the
22 | source storage device to update the source storage device; and

23 copying the snapshot volume to the destination storage device, wherein the copied
24 snapshot volume maintains a copy of a data on the destination storage device as the data
25 existed on the source storage device at the begin time.

1 51. (Currently Amended) A system to make a copy of data in a database, comprising:
2 a process executing on a processor of the system configured to initiate a copy op-
3 eration of a source storage device to a destination storage device, wherein the copy opera-
4 tion is performed in segments and each segment is a range of data bytes of the source
5 storage device, the copy operation started at a begin time;
6 the system configured to maintain a snapshot volume that includes each block of
7 the source storage device that has a write request directed to that block during the course
8 of the copy operation;
9 the system is further configured to receive a write request directed to the range of
10 data bytes currently being copied to the destination storage device;
11 in response to determining that a particular range of the range of bytes to be modi-
12 fied by the write request range has been copied to the snapshot volume, the system fur-
13 ther configured to continue the copy operation to the destination storage device using one
14 or more bytes of the particular range of data bytes from the snapshot;
15 in response to determining that a particular range of the range of bytes to be modi-
16 fied by the write request range has not been copied to the snapshot volume, the system is
17 further configured to hold the write request until the particular range of the range of bytes
18 to be modified by the write request range are copied to the snapshot volume;
19 after completion of writing the particular range of the range of bytes to be modi-
20 fied by the write request range to the snapshot volume, the system is further configured to
21 execute the write request on the source storage device to update the source; and
22 the system is further configured to copy the snapshot volume to the destination
23 storage device, wherein the copied snapshot volume is configured to maintain a copy of a
24 data on the destination storage device as the data existed on the source storage device at
25 the begin time.

1 52. (Currently Amended) A computer-readable storage media containing executable
2 program instructions executed by a processor, comprising:

3 program instructions that start a copying operation of a source storage device to a
4 destination storage device, wherein the copy operation is performed in segments and each
5 segment is a range of data bytes of the source storage device, the copy operation started
6 at a begin time;

7 program instructions that maintain a snapshot volume that includes each block of
8 the source storage device that has a write request directed to that block during the course
9 of the copy operation;

10 program instructions that receive a write request directed to a particular range of
11 the range of data bytes to be modified by the write request range that currently is being
12 copied to the destination storage device;

13 in response to determining that the particular range of the range of bytes to be
14 modified by the write request range has been copied to the snapshot volume, program
15 instructions that continue the copy operation to the destination storage device using one
16 or more bytes of the particular range of range of data bytes from the snapshot;

17 in response to determining that the particular range of the range of bytes to be
18 modified by the write request range ~~have~~has not been copied to the snapshot volume,
19 program instructions that hold the write request until the particular range of the range of
20 bytes to be modified by the write request range are copied to the snapshot volume;

21 program instructions that, after completion of writing the particular range of the
22 range of bytes to be modified by the write request range to the snapshot volume, execute
23 the write request on the source storage device to update the source storage device; and

24 program instructions that copy the snapshot volume to the destination storage de-
25 vice, wherein the copied snapshot volume maintains a copy of a data on the destination
26 storage device as the data existed on the source storage device at the begin time.

1 53. (Currently Amended) The storage system of claim 23, wherein the storage system is
2 further configured to send one or more commands by using an out-of-band protocol.

- 1 54. (Previously Presented) The method of claim 31, further comprising:
2 in response to determining that the write request range does not fall within the
3 particular range of the range of data bytes of the source storage device being copied, de-
4 termining if the write request range is directed to a next particular range of the range of
5 data bytes that has not yet been written to the snapshot; and
6 in response to determining that the write request range is directed to the next par-
7 ticular range of the range of data bytes that has not yet been written to the snapshot, copy-
8 ing the next particular range of the range of bytes not yet written to the snapshot.